

CONFIDENTIAL

SOCIETY vol.117, No.2, p. 222-224 (1970), as such miniature, lightweight and high performance rechargeable battery, development has been proceeded of rocking chair type lithium ion batteries (which are so-called lithium-ion batteries) in which, for instance, a carbonous material such as graphite is used as an anode active material and an intercalation compound incorporating a lithium ion is used as a cathode active material, wherein lithium is stored in the carbonous material as the anode active material by intercalating said lithium at intercalation sites in the carbonous material in the battery reaction upon charging. Some of these lithium-ion batteries have been put to practical use. In these lithium-ion batteries, by using the carbonous material as a host material capable of intercalating lithium as a guest material at the intercalation sites as the anode, occurrence or growth of a lithium dendrite upon charging is prevented to achieve a desired charge-and-discharge cycle life.--

Please replace the paragraph beginning on page 6, line 23, and ending on page 8, line 20, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

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--In order to improve such shortcomings relating to the mechanical strength of the ion conductor structural body, Japanese Unexamined Patent Publication No. 299119/1993 (hereinafter referred to as Document 5) discloses an ion conductor structural body comprising a polymer phase having a high polarity and a polymer phase having a low polarity as a retaining phase. However, the ion conductor structural body disclosed in Document 5 has a disadvantage such that the low polarity polymer phase does not function as an ion conductor phase and because of this, the ion conductivity is insufficient. Besides, Japanese Patent Publication No. 3045120 (hereinafter referred to as Document 6) discloses an ion conductor structural body in which an alkylene oxide derivative having a substituent group comprising a liquid crystalline compound is used. Japanese Unexamined Patent

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Publication No. 303905/1993 (hereinafter referred to as Document 7) discloses an ion conductor structural body in which a polymer matrix obtained by curing a polyether group-bearing monomer is used. However, any one of the ion conductor structural bodies disclosed in Documents 6 and 7 has a disadvantage such that because the polymer matrix structure is irregular, the ion dispersing property is inferior and the ion conductivity is insufficient. Further, Japanese Unexamined Patent Publication No. 324114/1997 (hereinafter referred to as Document 8) and Japanese Unexamined Patent Publication No. 106345/1998 (hereinafter referred to as Document 9) disclose ion conductor structural bodies comprising a polymer matrix in which a polymer whose glass transition temperature is low is used. However, these ion conductor structural bodies disclosed in Documents 8 and 9 have disadvantages as described in the following. That is, the polymer chain of the polymer matrix is likely to be softened and because of this, the mechanical strength of the ion conductor structural body is insufficient. In Documents 8 and 9, it is described that a plasticizer is not necessary to be used. However, in accordance with the techniques described in Documents 8 and 9 except for using a plasticizer, the present inventors prepared a gel-like ion conductor structural body comprising a polymer matrix in which a plasticizer is used and an evaluation was conducted. As a result, it was found that the softening temperature of the polymer matrix is lowered due to the plasticizer. In addition, the rechargeable battery in which such gel ion conductor structural body is used was found to have a disadvantage in that when the battery temperature is increased, the anode and the cathode begin to suffer from internal shorts between them.--

✓ Please replace the paragraph beginning on page 28, line 3, and ending on page 29, line 19, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

3

--As shown in FIG. 1(a), the side chain portion 102 and the main chain portion 101 of a polymer chain constituting a polymer matrix are respectively orientated. It is considered that this makes it possible to form a matrix structure comprising a regular polymer chain. In addition, as shown in FIG. 1(a), the polymer chain constituting the ion conductor structural body of the present invention forms the crosslinking bond 103. It is considered that this makes it possible to form a strong matrix structure having a structural regularity and because of this, an ion conductor structural body having an excellent mechanical strength is afforded. At this time, because the side chain portion 102 containing the polyether group 105 and the alkyl group 106 is orientated in a fixed direction as shown in FIG. 1(a), an ion conducting path 104 in which polyether groups having a polarity are arranged is formed in a fixed direction. Thus, it is considered that ions are made to be more readily mobilized in an ion conducting path direction in comparison with a case shown in FIG. 1(b) wherein polyether groups 105 are randomly present without being orientated in a fixed direction and wherein no ion conducting path is formed, and this situation provides an improved ion conductivity. Specifically, when the ion conducting path 104 is formed in a fixed direction as shown in FIG. 1(a), ions are capable of readily mobilizing along the ion conducting path. But in the case shown in FIG. 1(b), wherein no ion conducting path is formed, ions cannot mobilize in a fixed direction. However, the ions mobilize in a complicated manner to detour or the like and therefore, their mobilizing path inevitably becomes longer. The ion conductivity is increased in proportion to the ion concentration and the ion traveling speed in an inter-electrode direction. Therefore, when the number of ions and their mobility are the same in a given space of the ion conductor structural body, as the ion mobilizing path is shortened, the ion traveling speed in the inter-electrode direction is increased to increase the ion conductivity. Therefore, the ion conductivity in a direction along the ion conducting path

B3
Contd.

104 of FIG. 1(a) is improved in comparison with that in a direction that is different from said direction, and therefore, the ion conductivity exhibits anisotropy.--

Please replace the paragraph beginning on page 51, line 5, and ending on page 51, line 19, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B4

--Here, when the foregoing general formula (1) is E and the foregoing general formula (2) is F, W_1 has a structure represented by E_m and W_2 has a structure represented by F_n , or each of W_1 and W_2 has a structure represented by $E_m F_n$, $E_j F_m E_n$, $F_j E_m F_n$, $(EF)_n$, $(EFE)_n$ or $(FEF)_n$. Here, for instance, EF indicates a structure comprising E and F. EFE indicates a structure comprising E, F, and E, which are arranged while being connected with each other. E_n , E_m and E_n indicate respectively a structure in which a unit comprising E is repeated j, m or n time(s). F_j , F_m and F_n indicate, respectively, a structure in which a unit comprising F is repeated j, m or n time(s). $(EF)_n$ indicates a structure in which a unit comprising E and F is repeated n time(s). Numbers j, m and n are, respectively, a positive integer greater than 1.--

Please replace the paragraph beginning on page 53, line 21, and ending on page 54, line 7, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B5

--To control the glass transition temperature of the ion conductor structural body can be performed by controlling the glass transition temperature of the polymer matrix itself, which constitutes the ion conductor structural body, or by increasing the solvent content in the ion conductor structural body. To control the glass transition temperature of the polymer matrix itself can be performed by forming the polymer matrix

B5
Circled.

using a polymer whose glass transition temperature is low, or in the case where the polymer matrix has such a crosslinking structure as described in the above, by increasing or decreasing the crosslinking density of the crosslinking structure.--

Please replace the paragraph beginning on page 63, line 24, and ending on page 64, line 11, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

b6

--Step A: A first monomer having a side chain containing an alkyl group of 6 or more carbon atoms and a polyether group in accordance with the general formula (1) a given solvent and a given electrolyte are mixed. If required, a second monomer whose side chain having one or more kinds of polar groups selected from the group consisting of polyether group, cyano group, amino group and amide group, and a polymerization initiator are additionally mixed. Further, if required, a third monomer capable of forming a crosslinking structure is also additionally mixed. Thus, a mixture is obtained. The resultant mixture is stirred until the mixture is homogenized.--

✓ Please replace the paragraph beginning on page 93, line 15, and ending on page 94, line 13, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

b7

--In the case where the rechargeable battery is a rechargeable lithium battery in which oxidation-reduction reaction of lithium ion is used, as the material used in the anode active material layer 403, there can be mentioned materials capable of retaining lithium upon charging such as lithium metals, metals capable of being electrochemically alloyed with lithium, and carbonous materials and transition metal compounds which are capable of intercalating lithium. Such metal capable of being electrochemically alloyed

with lithium can include Bi, In, Pb, Si, Ag, Sr, Ge, Zn, Sn, Cd, Sb, Tl, and Hg. The metal preferably comprises an alloy having an amorphous phase, particularly an amorphous alloy of Sn, from a standpoint of improving the adhesion of the anode to the ion conductor structural body. The transition metal compound can include transition metal oxides, transition metal nitrides, and transition metal carbides. The transition metal element of these transition metal compounds can include metal elements having a d-shell or f-shell. Specific examples of such metal element are Sc, Y, lanthanides, actinides, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, Re, Fe, Ru, Os, Co, Rh, Ir, Ni, Pb, Pt, Cu, Ag, and Au. Of these, Ti, V, Cr, Mn, Fe, Co, Ni and Cu, which belong to the first transition system metal elements, are particularly preferable.--

Please replace the paragraph beginning on page 96, line 8, and ending on page 97, line 4, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

--In the case where the rechargeable battery is a rechargeable lithium battery in which an oxidation-reduction reaction of a lithium ion is used, as the material used in the cathode active material layer 405, there can be mentioned transition metal compounds that are capable of retaining lithium upon discharging and which are capable of intercalating lithium. Such transition metal compound can include transition metal oxides, transition metal nitrides, and transition metal carbides. The transition metal element of these transition metal compounds can include metal elements having a d-shell or f-shell. Specific examples of such metal element are Sc, Y, lanthanides, actinides, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, Re, Fe, Ru, Os, Co, Rh, Ir, Ni, Pb, Pt, Cu, Ag, and Au. Of these, Ti, V, Cr, Mn, Fe, Co, Ni and Cu, which belong to the first transition system metal elements, are particularly preferable. In the case where a material containing no lithium is

B4
Cathode

used as the anode active material upon the fabrication of a rechargeable lithium battery, it is preferred to use a lithium-transition metal oxide compound containing lithium in advance as the cathode active material.--

✓ Please replace the paragraph beginning on page 97, line 13, and ending on page 97, line 16, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B4

--The electrically conductive auxiliary can include carbon blacks such as graphite, ketjen black and acetylene black, and powdery metallic material such as nickel powder.--

✓ Please replace the paragraph beginning on page 100, line 20, and ending on page 101, line 16, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B10

--The resultant mixture was heated to 40°C and well agitated so that the ingredients were homogeneously dissolved in the solution to obtain a mixture solution. As a radical polymerization initiator, 0.002 parts of azobisisobutyronitrile were added to the mixture solution. Then the mixture solution was introduced into a cell (corresponding to the polymerization vessel 301 in FIG. 3) formed by arranging two quartz glass plates whose one side face having a fluororesin layer formed thereon such that their fluororesin layer-bearing faces are opposed to each other while forming a gap with a thickness of 50 μm between them and sealing their periphery by a spacer made of Teflon. Here, when the aqueous contact angle of the fluororesin layer-bearing face of each quartz glass plate was measured, it was found to be 117°. Then, the cell was heated at 70°C for one hour, whereby the mixture solution in the cell was subjected to a polymerization treatment via a

B10
Contd.

polymerization reaction, whereby a polymerized product was formed in the cell. The polymerized product was taken out from the cell to obtain a film-like ion conductor structural body having a size of 6 cm (width) x10 cm (length) x50 μ m (thickness).--

Please replace the paragraph beginning on page 110, line 19, and ending on page 111, line 18, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B11

--Particularly, in each of Examples 6 to 10, 7 parts of n-dodecylpolyethyleneglycol (the number of ethyleneoxide group: 2) acrylate [Example 6], n-dodecylpolyethyleneglycol (the number of ethyleneoxide group: 5) acrylate [Example 7], n-dodecylpolyethyleneglycol (the number of ethyleneoxide group: 20) acrylate [Example 8], n-dodecylpolyethyleneglycol- (the number of ethyleneoxide group: 30) acrylate [Example 9], or n-dodecylpolyethyleneglycol (the number of ethyleneoxide group: 100) acrylate [Example 10] as the first monomer; 5 parts of polyethyleneglycol (the number of ethyleneoxide group: 9) ethylmethacrylate as the second monomer; and 0.4 parts of polyethyleneglycoldimethacrylate (the number of ethyleneoxide group: 23) as the third monomer (as a crosslinking agent) were added to an electrolyte solution obtained by mixing 60 parts of diethoxyethane, 60 parts of ethylene carbonate and 15 parts of lithium hexafluorophosphate as an electrolyte to obtain a mixture. The resultant mixture was heated to 40°C and well agitated so that the ingredients were homogeneously dissolved in the solution to obtain a mixture solution. Except for this, the procedures of Example 1 were repeated to obtain a film-like ion conductor structural body in each case.--

Please replace the paragraph beginning on page 115, line 2, and ending on page 116, line 5, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B12

--Particularly, in each of Examples 11 to 14, 10 parts of n-octadecyltetraethyleneglycolacrylate (the number of carbon atom of the alkyl group/the number of ethyleneoxide group = 4.5) [Example 11], n-octadecyldiethyleneglycolacrylate (the number of carbon atom of the alkyl group/the number of ethyleneoxide group = 9) [Example 12], n-dodecylpolyethyleneglycol (the number of ethyleneoxide group: 30)acrylate (the number of carbon atom of the alkyl group/the number of ethyleneoxide group = 0.4) [[Example 13], or n-octylpolyethyleneglycol (the number of ethyleneoxide group: 90) acrylate (the number of carbon atom of the alkyl group/the number of ethyleneoxide group=0.088) [[Example 14] as the first monomer; 5 parts of tetraethyleneglycolbutylmethacrylate as the second monomer; and 0.2 part of polyethyleneglycoldimethacrylate (the number of ethyleneoxide group: 13) as the third monomer (as a crosslinking agent) were added to an electrolyte solution obtained by mixing 61 parts of propylene carbonate, 61 parts of ethylene carbonate and 13 parts of lithium tetrafluoroborate as an electrolyte to obtain a mixture. The resultant mixture was heated to 40°C and well agitated so that the ingredients were homogeneously dissolved in the solution to obtain a mixture solution. Except for this, the procedures of Example 1 were repeated to obtain a film-like ion conductor structural body in each case.--

Please replace the paragraphs beginning on page 119, line 11, and ending on page 122, line 3, with the following paragraphs. A marked-up copy of the original paragraphs, showing the changes made thereto, is attached.

B13

--90 parts of a natural graphite fine powder were heat-treated at 2000°C in an argon gas stream and 10 parts of a polyvinylidene fluoride powder to obtain a mixture and the mixture was mixed with N-methyl-2-pyrrolidone to obtain a paste. The paste was coated on a surface of a copper foil, followed by drying at 150°C under reduced pressure,

whereby an electrode member having an electrode layer formed thereon was obtained.

Here, when the aqueous contact angle of the electrode layer was examined, it was found to be 65°. In this way, there were obtained two electrode members. A porous film made of polyethylene was sandwiched between the two electrode members such that the electrode layer-bearing face of each electrode member was laminated on one of the opposite faces of the porous film, whereby a retaining member having a stacked structure was obtained.

Then, a mixture solution (containing a radical polymerization initiator) prepared in accordance with the method of preparing the mixture solution in Example 1 and which was impregnated in the two electrode layers and the porous film of the retaining member. The retaining member thus treated was subjected to a polymerization treatment in the same manner as in Example 1. Thus, there was obtained a stacked film-like ion conductor structural body.

Examination

Examination was conducted of the stacked film-like ion conductor structural body obtained in this example as will be described below.

A stacked film-like sample obtained from the ion conductor structural body was analyzed by means of an infrared absorption spectrum analyzer, a nuclear magnetic resonance spectrum analyzer, and a mass spectrum analyzer. As a result, there were obtained results lead to a presumption that the monomers would have polymerized at their mixing ratio in the initial mixing stage, whereby a crosslinking structure was afforded in the polymer matrix of the ion conductor structural body. In order to confirm this presumption, a stacked film-like sample obtained from the ion conductor structural body was gradually heated up to 300°C. As a result, although oxidation occurred, no fusion phenomenon was observed. This confirmed that the polymer matrix of the ion conductor structural body contains a crosslinking structure chemically bonded thereto.

As well as in Example 1, a stacked film-like sample obtained from the ion conductor structural body was examined with respect to the orientation property using the polarization microscope, the viscoelasticity measuring apparatus (DMS), and the X-ray small angle scattering measurement apparatus. As a result, it is possible to consider that in the ion conductor structural body obtained in this example, the main chain portion of the polymer chain is orientated in parallel to the film plane and the side chain portion of the polymer chain is orientated in the thickness direction to the film plane.

Further, a s stacked film-like sample obtained from the ion conductor structural body was examined with respect to the ion conductivity in the same manner as in Example 1. As a result, there were obtained results indicating that the ion conductor structural body has an ion conductivity with an anisotropy. In addition, the ion conductivity of the sample of the ion conductor structural body at low temperature was examined. As a result, the ion conductor structural body was found to have an ion conductivity that is superior to that of the ion conductor structural body obtained in Comparative Example 4, which will be described later.--

Please replace the paragraph beginning on page 122, line 22, and ending on page 123, line 1, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

--The resultant mixture was heated to 40°C and well agitated so that the ingredients were homogeneously dissolved in the solution to obtain a mixture solution. After this, following the procedures of Example 1, there was obtained a film-like ion conductor structural body.--

Please replace the paragraph beginning on page 125, line 2, and ending on page 125, line 14, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B15
--11 parts of polyethyleneglycol (the number of ethyleneoxide group: 9) methylmethacrylate and 0.2 part of polyethyleneglycoldimethacrylate (the number of ethyleneoxide group: 13) as a crosslinking agent were added to an electrolyte solution obtained by mixing 61 parts of propylene carbonate, 61 parts of ethylene carbonate and 13 parts of lithium tetrafluoroborate as an electrolyte to obtain a mixture. The resultant mixture was heated to 40°C and agitated so that the ingredients were homogeneously dissolved in the solution to obtain a mixture solution. After this, following the procedures of Example 1, there was obtained a film-like ion conductor structural body.--

Please replace the paragraph beginning on page 126, line 11, and ending on page 127, line 4, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B16
--5 parts of polyethyleneglycol (the number of ethyleneoxide group: 20)methylmethacrylate having an alkyl group of 1 carbon atom; 6 parts of polyethyleneglycol (the number of ethyleneoxide group: 9) methylmethacrylate; and 0.2 part of polyethyleneglycoldimethacrylate (the number of ethyleneoxide group: 13) as a crosslinking agent were added to an electrolyte solution obtained by mixing 61 parts of propylene carbonate, 61 parts of ethylene carbonate and 13 parts of lithium tetrafluoroborate as an electrolyte to obtain a mixture. The resultant mixture was heated to 40°C and agitated so that the ingredients were homogeneously dissolved in the solution to obtain a mixture solution. After this, following the procedures of Example 1, there was obtained a film-like ion conductor structural body.--

Please replace the paragraphs beginning on page 129, line 12, and ending on page 130, line 22, with the following paragraphs. A marked-up copy of the original paragraphs, showing the changes made thereto, is attached.

B17
--The procedures of Example 15 were repeated, except that as the mixture solution, a mixture solution prepared as described below was used, to obtain a stacked film-like ion conductor structural body.

11 parts of polyethyleneglycol (the number of ethyleneoxide group: 9) methylmethacrylate and 0.2 parts of polyethyleneglycoldimethacrylate (the number of ethyleneoxide group: 13) as a crosslinking agent were added to an electrolyte solution obtained by mixing 61 parts of propylene carbonate, 61 parts of ethylene carbonate and 13 parts of lithium tetrafluoroborate as an electrolyte to obtain a mixture. The resultant mixture was heated to 40°C and agitated so that the ingredients were homogeneously dissolved in the solution to obtain a mixture solution. Except for this, following the procedures of Example 15, there was obtained a stacked film-like ion conductor structural body.

Examination

Examination of the stacked film-like ion conductor structural body obtained in this comparative example was conducted as described below. As well as in Example 1, a sample obtained from the ion conductor structural body was examined with respect to the orientation property using the polarization microscope, the viscoelasticity measuring apparatus (DMS), and the X-ray small angle scattering measurement apparatus. As a result, it was found that in the ion conductor structural body obtained in this comparative example, the main chain portion and the side chain portion of the polymer chain are not orientated. Further, a sample obtained from the ion conductor structural body was examined with respect to the ion conductivity in the same manner as in Example 1. As a

B17
Cen. 11

result, it was found that the ion conductivity in the thickness direction is substantially the same as that in the film plane direction.--

Please replace the paragraph beginning on page 142, line 22, and ending on page 143, line 21, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B18

--There was provided a mixture solution prepared by mixing a mixture comprising 5 parts of n-dodecylpolyethyleneglycol(the number of ethyleneoxide group: 20) acrylate; 6 parts of polyethyleneglycol (the number of ethyleneoxide group: 9) methacrylate; 0.2 part of polyethyleneglycoldimethacrylate (the number of ethyleneoxide group: 13) as a crosslinking agent; and 0.04 part of 1-hydroxycyclohexylyphenylketone as a radical polymerization initiator with an electrolyte solution of 1 mole/dm³ obtained by dissolving lithium tetrafluoroborate in a mixed solvent obtained by mixing propylene carbonate and dimethyl carbonate at a volume ratio of 1:1. 140 parts of the mixture solution were impregnated in the anode active material layer 403 of the anode 404, followed by subjecting to a polymerization treatment by irradiating ultraviolet light of 10 mW/cm² for one hour, whereby the anode active material layer 403 of the anode 404 was made to contain an ion conductor structural body formed therein. Similarly, 140 parts of the mixture solution were impregnated in the cathode active material layer 405 of the cathode 407, followed by subjecting to a polymerization treatment by irradiating ultraviolet light of 10 mW/cm² for one hour, whereby the cathode active material layer 405 of the cathode 407 was made to contain an ion conductor structural body formed therein.--

✓ Please replace the paragraph beginning on page 145, line 13, and ending on page 145, line 24, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B19

--Separately, there was provided a mixture solution prepared by mixing a mixture comprising 7 parts of n-octadecylpolyethyleneglycol (the number of ethyleneoxide group: 10) acrylate; 4 parts of polyethyleneglycol (the number of ethyleneoxide group: 6) methylmethacrylate; 0.3 part of polyethyleneglycoldimethacrylate (the number of ethyleneoxide group: 23) as a crosslinking agent; and 0.002 part of azobisisobutyronitrile as a radical polymerization initiator with an electrolyte solution obtained by mixing 61 parts of diethyl carbonate, 61 parts of ethylene carbonate, and 13 parts of lithium hexafluorophosphate as an electrolyte.--

✓ Please replace the paragraph beginning on page 146, line 22, and ending on page 147, line 21, with the following paragraph. A marked-up copy of the original paragraph, showing the changes made thereto, is attached.

B20

--There was provided a mixture solution prepared by mixing a mixture comprising 5 parts of n-dodecylpolyethyleneglycol (the number of ethyleneoxide group: 20) acrylate; 6 parts of polyethylene glycol (the number of ethyleneoxide group: 9) methacrylate; 0.2 part of polyethyleneglycoldimethacrylate (the number of ethyleneoxide group: 13) as a crosslinking agent; and 0.04 part of 1-hydroxycyclohexylphenylketone as a radical polymerization initiator with an electrolyte solution of 1 mole/dm³ obtained by dissolving lithium tetrafluoroborate in a mixed solvent obtained by mixing propylene carbonate and dimethyl carbonate at a volume ratio of 1:1. 140 parts of the mixture solution were impregnated in the anode active material layer 403 of the anode 404, followed by subjecting to a polymerization treatment by irradiating ultraviolet light of 10 mW/cm² for one hour, whereby the anode active material layer 403 of the anode 404 was made to contain an ion conductor structural body formed therein. Similarly, 140 parts of the mixture solution were impregnated in the cathode active material layer 405 of the cathode 407, followed by subjecting to a polymerization treatment by irradiating ultraviolet